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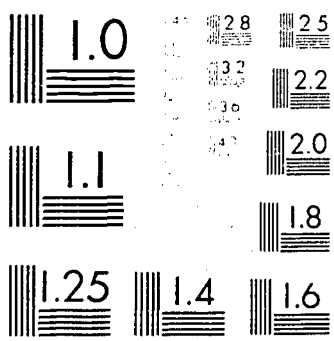

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ABSTRACT

These guidelines are designed to help Maryland's educators and citizens make informed choices about the types of facilities they will provide for teaching science in grades K-12. They are not a blueprint for facilities nor are they an attempt to standardize all science programs or facilities, but seek to identify elements to consider, people to involve, tasks to be completed, and a schedule to follow in planning for the renovation or construction of a school science facility. Sections discuss the planning process, the science program, facilities, equipment, safety, space requirements and utilization, and a planning timetable. (Author/MLF)

MARYLAND SCHOOL SCIENCE FACILITIES GUIDELINES

1977

A Publication of
The Division of Instruction, Maryland State Department of Education, and
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Table of Contents

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Foreword

Maryland School Science Facilities Guidelines are designed to help Maryland's educators and citizens make informed choices about the types of facilities they will provide for teaching science in grades K-12. They are not a blueprint for facilities nor are they an attempt to standardize all science programs or facilities. They are a guide which identifies points to consider and people to involve in the facilities planning process.

Although few of our citizens become scientists; all are influenced by the impact of science on their lives. It is, therefore, important that each Maryland student have opportunities to study the ideas, products, and processes of science. The facilities provided must accommodate all aspects of science programs. At the same time, science must be kept in perspective wtih the total educational program for the schools—the facilities provided for science must, therefore, integrate smoothly and functionally into the schools' total planning.

This publication offers choices for designing the best possible science facility for a particular school. These choices may be combined in many ways to accommodate the philosophies of different schools.

David W. Hornbeck
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Introduction

This document seeks to identify elements to consider, people to involve, tasks to be completed, and a schedule to follow in planning for the renovation or construction of a school science facility. In following sections, the planning process, the science program, facilities, equipment, safety, space requirements and utilization, and a planning timetable are discussed.

It is a publication designed to serve as a planning guide for use in the construction and renovation of science facilities in Maryland public elementary and secondary schools. It is not a blueprint for facilities; nor is it an attempt to standardize all science programs or facilities. Rather, it is a guide which identifies points of consideration and resource individuals in the science facilities planning process.

This document attempts to provdie answers to the following questions:

- Who should be involved in planning science facilities?
- What is the role of each participant in planning these facilities?
- What are the steps and time sequences in the planning process?
- What is science?
- What are viable science programs K-12?
- What facilities are needed for the various science programs?
- What equipment is needed for the various science programs?
- What faculty and staffing are needed for the various science programs?

A school science facility must accommodate the instructional program it serves. Therefore, the planning process must assure the best possible environment for students to pursue instruction. The basis for that planning is the science program for which the facility will be constructed.

Science is process as well as knowledge. Children should study science by being involved not only with its content, but also with its processes. The science facility must accommodate both. Science study requires a variety of unique instructional materials as well as those materials common to all of education. A science facility must accommodate this variety. In some cases, modifications to basic classrooms or instructional areas will be required. In other cases, special facilities exclusively for the teaching and learning of science must be provided.

Planning must be a participatory process where views are aired and decisions made to provide a functional facility to accommodate the instructional program. Local supervisors and instructional personnel with advanced training in and responsibilities for the science program must be involved in planning the facility they will use. In addition, consultants from the Maryland State Department of Education with expertise in science and facility planning can provide additional perspectives and options to the planning-decision making process. They should be involved in helping plan local facilities. Any science planning group should be a part of the total school planning organization to ensure coordination with the philosophy of total school programming.

Science—A Point of View

Although a relatively small number of our citizens will become scientists, all of them will be greatly affected by science, its products, and the changes it brings about. Furthermore, all citizens need to make certain adjustments in light of new scientific developments. The progress and security of democracy are inescapably dependent on scientific achievements and on the use of scientific knowledge to improve living conditions in the world community.

Development of an understanding of the ideas, products, and processes of science, as well as the ability to adjust to the changes resulting from scientific discovery, is a vital role of education. Therefore, science education must be more than an accumulation of facts. It must develop an ability and a willingness to identify problems and work logically toward their solutions, and a desire to apply knowledge and principles toward self-improvement and community improvement in areas such as health, community resources, and living standards in general.

In school science programs, considerable attention must be given to the processes as well as to the products of scientific investigation. Identifying problems; forming hypotheses; experimenting; evaluating; forming conclusions; and experiencing discovery, failure, and success can encourage students in the true spirit and feeling of science. When students experience science as scientists do themselves, some may be inspired to become scientists, while others may simply come to understand and respect science and the scientist's problems and accomplishments.

Science makes its greatest contribution to the individual's happiness, success, security, and understanding when it is kept in proper perspective with the entire educational program. The interrelationships and the profound impact of science on other phases of education and human endeavor make it a vital and integral part of the daily lives and thinking of all citizens.

The Science Facility

The science facility must accommodate all aspects of the science program. There are basic areas of consideration that are applicable to all facilities and must be addressed as part of the total planning process:

Space Must Be Functional.

- It must provide adequately for all of the activities planned for the program (biology, earth science, etc.).
- It must accommodate the natural interrelationships that exist in the total program.
- It must accommodate the natural interrelationships that exist among the various curricular areas of the total school program.

Space Must Be Expandable.

Provision should be made for internal and external expansion produced by population shifts, community development, and more significantly, program changes or increases in program enrollment. Construction components should be selected, at least in part, on their abilities to expand and contract as necessary.

Provision For Flexible Space Should Be Considered.

Changes in methodology, equipment, and materials of instruction, resulting from advances in technology, may necessitate restructuring given spaces to accommodate such changes. Wherever practical, the use of fixed items should be minimized to allow maximum possible flexibility.

Spaces Should Be Designed For Multiple Functions.

Multiple usage of given instructional areas should be planned and encouraged. When spaces for specific and restricted functions must be provided, they should be minimal.

Maximum Cost Effectiveness Should Be Of Paramount Concern.

Careful and wise use of available capital monies must be ensured. Performance criteria for the construction materials and equipment selected must be developed. These criteria should consider not only the initial costs, but also costs of maintenance and long range use.

Staffing Patterns Should Be Considered In The Planning Decisions.

Staffing patterns are ever changing and must be carefully studied in designing instructional space as well as supporting facilities. Provision must be made to accommodate planned staffing patterns, as well as to provide flexibility for future changes in staffing patterns. Staffing decisions require a commitment by the central office staff that adequate staff will be provided for programs.

Use Of The Outdoors As Learning Environments Should Be Considered.

Whenever possible, land should be maintained in its natural state to aid environmental studies. Both aesthetics and natural study areas should be noted in such sites. Obviously, sites will vary considerably; therefore, in the early study of sites, potential environmental areas should be identified and protected as decisions of structure location are made. In addition, planning with park and recreational personnel for maximum use of site development for other educational activities should be part of the early planning process.

Facilities Must Conform To Local And State Health and Safety Codes And Regulations.

Local and state health and safety codes and regulations must be addressed throughout the entire planning, design, and construction processes. Oversights will not only cause costly revisions, but they could result in physical harm to occupants.

The Planning Process

Educators make numerous decisions in planning educational facilities. Together, these decisions direct the architect designing the facility.

The importance of planning cannot be overemphasized. The building's functional value, its expandability, its flexibility, as well as economic factors, and the health and safety of its occupants, should be given primary consideration.

The planning process will take longer with many persons involved, but it should make many options and points of view available which will eventually lead to valid decisions which will form the basis of a functional facility.

The Development Of A New or Renovated Facility Must Be Orderly.

The steps in the planning process may vary. The following steps are one possible sequence:

- Site selection or confirmation.
- Formation of planning committee and subgroups.
- Committee discussions and decisions on program, philosophy, content, staffing, organization, etc.
- Preparation of educational specifications.
- Interpretation of educational specifications to the project architect.
- Development of schematic design documents.
- Review of the schematic design in relation to the educational specifications.
- Development and approval of design development documents.
- Development and approval of construction documents.
- Review and approval of furniture and equipment drawings and lists.
- Bidding.
- Contract award and construction.
- Acceptance of project.
- Post-occupancy evaluation.

Educational Specifications Are The Foundation For All Planned Facilities.

Educational specifications are written documents that describe program, philosophy, and building implications for construction projects. They are written by educators, both specialists and generalists, and are a recording of decisions about activities for students, teachers, and administrators, and descriptions of spaces to support such activities.

Specifications, when completed, become base documents from which project architects proceed with drawings. They also serve educators as "bench marks" for checking the progress of projects based on the planned programs.

The documents are prepared by central planning committees with continued input from specialized subcommittees.

Central Planning Committees Play Key Roles In Decision Making.

Although many persons may participate from time to time in the planning process, certain individuals must be involved as core decision-makers. These include the superintendent and/or his/her representative(s), the local educational agency's director of facilities planning, and the various curriculum and/or instructional specialists.

The local science specialist must also be a committee member from the onset of the project. This assures his or her participation in the total project and utilizes his or her knowledge and expertise in the formation of both science programs and science facilities.

Participation and involvement by school principals, teachers, students, lay citizens, and/or community representatives, and representatives of local, regional, State or federal agencies are desirable. Their roles may be diverse, but they may bring valuable divergent points of view or frames of reference to the process.

Subject Area Or Interest Area Committees Should Be Established To Support And Advise Representatives Of Central Planning Committees.

Science subcommittees should be organized to assist and give direction through local science supervisors to central planning committees. The subcommittee members should be knowledgeable science and science instruction persons. The members may include science teachers, state science consultants, and community science experts.

Central Planning Committees And Subcommittees Should Be Involved Throughout The Processes Of Facilities Development.

All major project milestones require reviews by functional committees. Specifically, committees should function in the following steps:

Central Planning Committee(s)

- Preparation of educational specifications.
- Interpretation of the educational specifications to the project architect.
- Development of schematic design documents.
- Review of schematic design documents.
- Review of design development documents.
- Review of construction documents.
- Review of furniture and equipment, drawings, and lists.
- Acceptance of project.
- Post-occupancy evaluation.

Subject Area Committee(s)-Science

- Preparation of educational specifications.
- Development of schematic design documents.
- Review of schematic design documents.
- Preparation and review of furniture and equipment, drawings, and lists.
- Post-occupancy evaluation.

Summary of Committees and Responsibilities

Central Planning Committee(s)

This group of both generalists and specialists develops the overall philosophy of a project, as well as making the decisions concerning program and concurrent facilities.

Membership	Role
Superintendent/or Representative	As chief school official, final decisions concerning the facility rest with the superintendent.
Facility Planner	This expert in both education and facilities should serve as a resource person to the group directing decisions.
Local Instructional Specialist (Science Supervisor)	The committee expert in science should have the decision-making authority to project programs and their facility implications.
Principal	The principal should serve as a generalist and help coordinate the project within the total school program and guide the group in the effective administration of the school.
Teachers	Selected teachers should serve as experts in building usage and assist in decisions in their fields of expertise.
Students	Students should participate to guide the committee toward decisions compatible with their needs and to assist in decisions for specific student-centered areas.

Science Subcommittee

This group should provide consultive services in science matters through the local science supervisor to the Central Planning Committee. They should bring knowledge and experience in developing science programs and needed facilities.

Membership	Role
Science Teachers	Science teachers should serve as generalists, as users of science facilities who evaluate science programs, equipment, and facilities.
State Science Consultants	State science consultants should assist in transmitting information about new national trends as well as sharing what other local systems are doing in science. They may arrange for visitation to other good science facilities.
Community Persons	Many community persons work in scientific fields and can provide different points of view for the subgroup and should be utilized if possible.

The Science Program

Youngsters are by nature inquisitive and eager to learn about the world and their environment. They constantly ask such questions as: "How do living things grow?" "What makes things move or stand still?" "What is this particular thing made of?" They deal most effectively with concrete ideas — through things that are near in time and space. For the educator, these natural motivational influences are important factors for planning and implementing meaningful science programs. Such programs must offer information about relevant questions of particular interest. Science teaching should foster excitement and enjoyment in problem-solving situations that foster continuing discovery and knowledge.

Science education currently emphasizes developing students' abilities to understand scientific principles and concepts through direct involvement in scientific processes. They must have frequent experience in problem solving, discovery, and inquiry if they are to understand what science is and how it works. While science content is the keystone of any science program, educators must realize that scientific knowledge is expanding so rapidly that it is impossible for any program to encompass any given field. Thus, students must understand major principles and concepts of science and be able to use the basic processes of continuing scientific study. Concern for the wise use of their physical and biological environment and thoughtful regard for present and future generations are essential outgrowths of the basic understandings and emphases of science.

The goal of K-12 science programs should be to produce scientifically literate ctiizens.

To become scientifically literate, a person needs to:

- Acquire knowledge which can be used to explain, predict, and understand natural phenomena.
- Recognize that the meaning of science depends as much on its inquiry process as on its conceptual schemes and thus needs to engage in the processes of science and apply these processes in appropriate everyday situations.
- Acquire scientific attitudes and learn to apply these attitudes appropriately in daily experiences.
- Understand that science is one way but not the only way of viewing natural phenomena, and that there are different points of view within the sciences themselves.
- Understand the various interrelationships among science, technology, and society to develop intelligent decisions and take active part in these interrelationships.
- Appreciate the interaction of science and technology, recognizing that each reflects as well as stimulates the course of future developments, but that science and technology do not progress at equal rates.
- Recognize that knowledge in science evolves and that the knowledge of one generation may subsume, overturn, or complement previous knowledge.
- Learn and develop numerous useful psychomotor skills through the study of science.
- Acquire a variety of interests in and enthusiasm for science that may lead to vocational and/or avocational interests.*

SCIENCE PROGRAM TRENDS IN THE ELEMENTARY SCHOOL

The following are current trends in elementary science education:

- Increased emphasis upon the active in-

* modified from *Scheme for Scientific Literacy*, Anne Arundel County Unified Science Approach Project.

volvement of pupils in the scientific processes of inquiry and discovery.

- Increased emphasis upon teachers' roles in guiding pupils to engage in inquiry and discovery.
- Increased opportunities for individuals and small groups of children to participate in laboratory experiences that are relatively unstructured and for which the outcome may not necessarily be known.
- A broadening of the setting for laboratory experiences to include not only classrooms and science centers, but also specialized facilities such as earth space laboratories, outdoor education sites, the community, and various other locations where suitable resources may be available.
- Greater emphasis upon pupil use of multiple resources in seeking information related to science problems:

Increased use of reference and trade books;

Availability and use of an increasing variety of films and other audiovisual aids as resources in problem solving;

Increasing involvement of resource persons knowledgeable in science and related fields to bring additional information, experience, and motivation to the classroom.

- An increase in the kinds and numbers of formal and informal science equipment available for pupil use.
- Increased emphasis upon the importance of mathematical skills, concepts, and language in making more precise and accurate descriptions in science.
- Increased attention to experimental science studies and the degree to which such studies should affect science programs for elementary schools.
- Recognition of the need for science teachers to be increasingly knowledgeable in the content and processes of science and in the planning and designing of meaningful science activities.
- Expanded in-service opportunities for teachers of science, including college courses, workshops, and institutes on the local, state, and national levels.

Program Recommendations

The following are recommendations for elementary school science programs:

1. Adequate time must be provided for a full program of science at all levels of the elementary school, as part of the basic program of education for every child.

Science permeates our lives. Its processes and products are intrinsic in much of what we think and do. It is important therefore, that all children begin early and continue throughout their schooling to develop the scientific literacy they need to understand their world and to live responsibly in a democratic society whose citizens bear the responsibility for decisions having to do with the furtherance of science and the utilization of both its intellectual and technological products.

Sufficient time must be provided in elementary school schedules for continuous science programs every year. Each week, a minimum of 120 minutes at the primary level and 180 minutes at the intermediate level should be allotted to science. Where science is integrated into the total curriculum, equivalent time should be provided for active inquiry-centered science experiences. Science is a major element in elementary school curriculum.

2. Science programs must be designed to help children attain a variety of accepted objectives, including skills and values.

Elementary science programs help children in a variety of ways. They give them skills. As they gain proficiency in observing, measuring, classifying, predicting, inferring, etc., they are able not only to learn science more efficiently but also to grasp other areas of the curriculum more readily. These processes and skills will be useful all their lives.

They give them knowledge. The science program helps children develop concepts about matter, energy, living things, and other aspects of their natural environment. They also help them learn about the nature of science; e.g., the need for data, the importance of reproducibility, and the tentative nature of scientific conclusions.

Finally, science programs give children opportunities to mature personally and socially — to develop values, such as self-confidence, concern for others, concern for the environment, and open-mindedness.

3. Elementary school science programs must involve every child in relevant, practical experiences.

Three reasons support such science programs. First, they are highly motivating because almost all children like such science experiences. Second, they practically guarantee success for every child. Through active involvement children learn to rely upon themselves — to manipulate equipment, to make their own observations, to come to their own conclusions. They are in control. Even the shyest or the slowest child gains confidence and self-respect. Finally, such programs produce results. They provide the ideal setting for learning concepts, for practicing and perfecting skills, and for gaining positive attitudes and deep appreciations. An added benefit is the special support science experiences lend to growth in the language arts. When children are manipulating and observing, they tend to learn new words easily and to talk unselfconsciously about their findings. This growth in oral language is good background and excellent motivation for improved reading and writing.

4. Science programs must give children a variety of indoor and outdoor experiences.

Many different kinds of activities are needed to achieve the objectives of elementary school science programs. Some of them are more or less unique to science; e.g., observing the environment, manipulating scientific equipment, making collections of natural objects, and visiting science museums, planetaria, and zoos.

The outdoors is the ideal setting for large parts of science programs. School playgrounds and campuses should be used frequently. Nearby parks, waterfronts, and other facilities offer further opportunities. In some schools, resident outdoor experiences are possible. These are usually interdisciplinary, but they frequently emphasize science-related activities.

The whole array of more generally useful experiences is also important in science teaching: language activities of all kinds; use of various media; arts and crafts activities; and most important of all, thinking and pondering activities, such as noting relationships, interpreting data, predicting, making inferences, drawing conclusions, and formulating models or explanations.

5. The science program must allow for pupil interaction and provide opportunities for children to work independently and in various kinds of groups.

Children learn science from working with things. They also learn from each other. As a matter of fact, some persons feel that students correct their misconceptions primarily by interacting with peers who express opposing points of view. Therefore, a classroom should provide a climate that promotes free inquiry and pupil interaction.

Although this kind of interchange is usually associated with small-group activity, science programs must not rely on this activity alone. Children achieve some science objectives best through independent study; others through large-group activity. Elementary science programs, therefore, must provide for all of these kinds of experiences.

6. Science programs must be flexible, allowing for alternative approaches and pupil and teacher options.

Science itself is open-minded and thrives best in a free, unhampered intellectual climate. Thus, by reason of consistency alone, elementary science programs should be flexible.

More persuasive reasons for programs that allow for pupil and teacher options are: a) There are many viable programs and teaching strategies that can be used to achieve the accepted objectives; b) Children vary widely in interests, abilities, and the ways in which they learn most easily; and c) Elementary school teachers also vary, particularly in their science backgrounds and teaching styles. In the interest of both learning efficiency and personal preferences, the science program should be flexible enough to allow for these differences. As long as teachers and pupils stay within the framework of an active inquiry-centered program, they should be free to choose areas for investigation and strategies for studying the topics they have selected.

7. Science programs must be related to children's experiences and to other areas of curricula.

Science can be taught as an integral part of elementary school programs. The variety of content and the motivating teaching strategies associated with science make it ideal for integrated learning. It is easy to relate language arts, social studies, mathematics, art, music, and physical education to science. However, when integrating science with other subjects, one must be careful not to neglect active science inquiry or to replace it entirely with reading and media activities. On the other hand, if taught separately, science must include experiences that help children relate it to their lives and their studies.

8. A successful elementary school science program must include definite plans for helping teachers gain the special skills they need to carry out active, inquiry-centered learning activities.

Even in the best science programs. rationale and point of view do not necessarily emerge in classroom practice, particularly when active inquiry-centered programs are replacing more traditional approaches.

Many teachers have been deprived of active inquiry-centered learning experiences in their own educations. Thus, supervisors and administrators have special responsibilities to provide helpful in-service training for this kind of teaching. The whole gamut of in-service activities, from professional study day-long programs through full semester courses must involve teachers in inquiry-centered, practical activities. Most teachers who have experienced this teaching style like to use it and find it very productive.

SCIENCE IN MIDDLE, JUNIOR, AND SENIOR HIGH SCHOOLS

Program Trends

- Science is taking its place as an integral part of an articulated sequence running from kindergarten through twelfth grade.
- The fusion or correlation of science with one or more subjects is fast disappearing; instead, articulation of science programs with other areas of the curriculum is being achieved through representation of various fields on curriculum-planning committees.
- Recognition of science as a creative, intellectual pursuit is gaining precedence over the definition of science as organized information and over science programs built around socioeconomic concerns or personal-social needs of youth.
- Efforts to improve science laboratory programs include the following:

Reduction of formal demonstrations and individual laboratory experiments in which the major purpose is verification. in favor of increased laboratory activities designed to elucidate principles and solve problems for which answers are not known in advance.

General rather than specific directions to students which lead to discovery and "open-ended" experiments.

Long-range, sustained laboratory activities.

Increased individual laboratory experiences at the middle and junior high school levels.

Improvement of individual projects being developed by students.

- More and better facilities and teaching materials are being provided for science. Among them are the following: sizeable annual allotments; increased variety of available materials; a tendency to break away from tradition to provide ingeniously designed and adaptable materials; a growing realization of the need for substantial petty-cash funds for all science departments; and efforts to plan new science laboratories with sufficient space and furnishings and with built-in flexibility in terms of presently accepted goals of science teaching, as well as principles of good design, attractiveness, durability, safety, and health.
- School systems are utilizing resource personnel from colleges and the community, particularly subject-matter specialists, in science curriculum-development programs, in seminar presentations, in classroom talks, and in auxiliary capacities, such as science-fair judges and career counselors.
- There is some disposition to extend science programs beyond the school day and year through evening and Saturday seminars, summer science camps and courses, and improved science-club activities, including before- and after-school sessions.
- Attempts are being made to develop courses for less able students which are more functional than the courses for average or above-average students.

Program Recommendations — Grades 5-9

9. Science programs shall be provided as part of the basic programs of education each year for all students in grades 5-9.

Today's pupils live in a society characterized by scientific enterprise and technological development which demands that individuals be scientifically literate. Fostering scientific literacy is essential to the maintenance of our standard of living.

Science teachers are responsible for developing scientific concepts and processes, as well as molding attitudes, establishing wholesome values and developing skills for making wise decisions. To this end, a continuous, sequential science program which fosters the development of the fundamental schemes relating to matter, energy, space, life, and change in a general non-repetitive manner is necessary.

Because science provides so many opportunities for learning and using problem-solving methods, all children, whatever their abilities, hopes, or ambitions, should study science. Students should have opportunities to learn the kinds of science that best serve their interests and needs.

10. Time shall be provided to accommodate a full program of science in grades 5-9.

Science experiences are essential, integral parts of modern educational programs and should be sequential and continuous throughout the school year. Time must be provided for individual and group activities in a variety of organizational patterns.

- In grades 5 and 6, a minimum of 200 minutes of instructional time should be provided each week, not including health-related instruction. A minimum of three weekly science experiences in a variety of time modules should be provided.
- In grades 7, 8, and 9, a minimum of 220 minutes of science instruction should be provided each week. Science instruction periods should be daily experiences. These time allotments do not include health-related instruction taught as separate units or classes.

11. Science experiences should provide:

For the acquisition of facts, concepts, and principles such as:

- The nature and structure of matter;
- Energy transformation and uses;
- The nature and structure of living things; and
- The nature of change.

Opportunities to develop skills, interests, and positive attitudes such as the abilities to:

- Perform fundamental operations;
- Perform manipulatory activities with science equipment
- Read and interpret science content, maps, graphs, etc.
- Define problems;
- Select hypotheses and test them experimentally; and
- Draw conclusions.

Opportunities to develop attitudes such as:

- Openmindedness; and
- Intellectual honesty.

Opportunities to develop appreciations of:

- Cause and effect relationships;
- Contributions of scientists; and
- Uses and application of science.

Opportunities to develop interests in science as recreational activities, hobbies, and careers.

12. Science experiences in grades 5-9 shall involve the learner in the processes of science.

Children learn through their perceptions of active, first-hand, multisensory experiences. Science perceptions are developed (reinforced/corrected) as children are provided with numerous opportunities to explore, to inquire, and to manipulate materials. The science laboratory becomes a potent environment for the formation of percepts, concepts, and generalization and a cogent force for skill development through "learning by doing." The middle school students are enthusiastic and responsive to laboratory activity. This approach provides pupils with an early start in learning the processes of science and promotes science hobbies, early vocational selection and election of science programs in future years.

13. Science teaching at the middle-junior high school level requires teachers with special skills, knowledge, and interests in the subject.

Every science teacher should meet Maryland State Department of Education standards for certification. Teachers should possess science skills as well as teaching skills. Children's questions and interests require science teachers to have strong backgrounds in science. The teachers should profit from their own scientific and pedagogical research and contribute to curriculum development as a result.

14. Science programs shall expose students to a variety of alternative learning experiences.

Diversity in the nature, interests, and maturity of learners; in the complexity and dimensions of science; and in the physical and administrative designs for instruction affords opportunities for a broad spectrum of learning experiences. Science programs shall define appropriate goals and provide avenues for capitalizing on these variable elements of teaching-learning environments.

• Science programs should provide opportunities for learning experiences using a variety of grouping patterns which cross age, grade, team, and subject lines.

Middle-junior high school children need to develop realistic and positive self-perceptions. A variety of grouping patterns and many occasions to improve their competencies, to achieve success, and to gain peer recognition await children studying science. Science programs extend opportunities for personalization.

• Science programs should afford opportunities for establishing a balance between individual and group learning experiences.

Success requires that persons function competently on individual bases and as team members; and that they be able to adjust readily to varieties of settings and operational plans. Science programs which emphasize laboratory activities afford frequent opportunities for pupils to exercise acquisitive, organizational, manipulative, and communicative skills on independent and shared bases. Evidences of interdependence and the values of interaction are more conclusive when learners are actively involved.

• Laboratory-centered science programs should provide for a variety of concomitant teaching styles.

Science programs are unique only in the extensiveness and intensiveness of their investigative activities and evolution from these experiences. A variety of other teaching styles and learning activities provides pupils with opportunities to support evidence, reinforce learnings, justify procedures and evaluate results.

• Science programs shall be sufficiently flexible to function effectively in settings ranging from self-contained to generalized open space.

Science teaching-learning environments must accommodate programs being offered.

• Science programs shall provide continuity between the elementary and secondary levels.

Science programs shall challenge youth to proficiency in a variety of learning experiences, to experiment with different processes, to think critically and creatively, and to assume greater responsibility for their learning.

15. Science programs should involve students in meaningful encounters with a variety of experiences.

Abundant, practical laboratory experiences, with adequate materials and facilities, utilizing the processes of science, are fundamental to all youth. Such alternative learning experiences require facilities with adequate space, arranged and equipped to provide for flexibility. On-site storage is essential. Careful planning and equipping of an instructional facility neither guarantees flexible utilization nor a variety of learning experiences. The teacher is the key and should be involved in planning facilities.

Field trips and the use of resource persons will provide students first-hand acquaintances with phenomena, opportunities to sharpen observational skills, increased relevance, and opportunities for application of understandings.

Planetaria visits and games will provide simulation experiences and translation from abstract to reality.

Printed materials spanning a range of reading levels should be available in science classrooms. Pamphlets, readers, and multiple texts will serve primarily as references to support laboratory observations and provide structure to the content area.

Audio-visual materials in the forms of tapes, charts, models, filmstrips, motion pictures, and single concept loops should be available to reinforce observations and provide further dimension to the experience.

16. Science experiences should be related to other school experiences.

Experiences in the areas of common human interests, problems, and problem solutions should be provided. The science experience has a relationship to other curricular areas such as mathematics, social studies, art, etc. To facilitate this interrelationship, science teachers need opportunities not only to meet and interact with other science teachers, but also to meet and plan with teachers of other subjects at the same grade level. Provisions for facilities and scheduling to accommodate this interaction must be made.

Program Recommendations — Grades 9-12

17. The secondary science program must be planned and administered to provide opportunities for any student to meet the general State standards for graduation.

Credits for graduation are earned in grades 9 through 12. However, provisions are made for alternatives to full four-year enrollment in recognition that such programs may not serve the best interest of some students.*

The general requirement specifies that the student must earn a minimum of 20 credits, eleven in specified areas, including two in science. The remaining nine credits may be chosen from offerings in any curricular field.

The graduation credit unit is defined in *Graduation Requirements for Public High Schools in Maryland*. Determination of a unit of credit is based on the satisfactory completion of coursework and the number of hours of instruction scheduled by the school. The time requirements for earning units of credit are based on a school year of 36 weeks; however, these time requirements are applicable to various flexible school year configurations:

1 credit	132 clock hours
½ credit	66 clock hours
⅓ credit	44 clock hours
¼ credit	33 clock hours*

Content areas listed below are a general guide for science programs, not an all-inclusive list of possibilities. Specific and integrated learning experiences may be developed within this content area list. Every effort should be made to assist students to select learning experiences appropriate to their future objectives and academic needs and accomplishments.

Earth and Space Science
General Science
Integrated Science
Life Science
Physical Sciences

18. Programs must provide at least two years of science for every student.

In addition to the two required units in science, students may use any of nine elective credits to select science courses or courses in any other discipline. In these electives, students should have a wide range of choices from courses flexible enough to meet the full range of student diversity. All students are not forced to take the same two years of science if they may select from a comprehensive program on the basis of interest, academic need, and student concerns.

19. Programs must provide opportunities for students to study science every year.

A wide selection of challenging courses should be provided. Opportunities for guided independent study should be provided for students who become interested in a particular aspect of or approach to the study of science. With such provisions, continuous science study can make a significant contribution to the individual's total education.

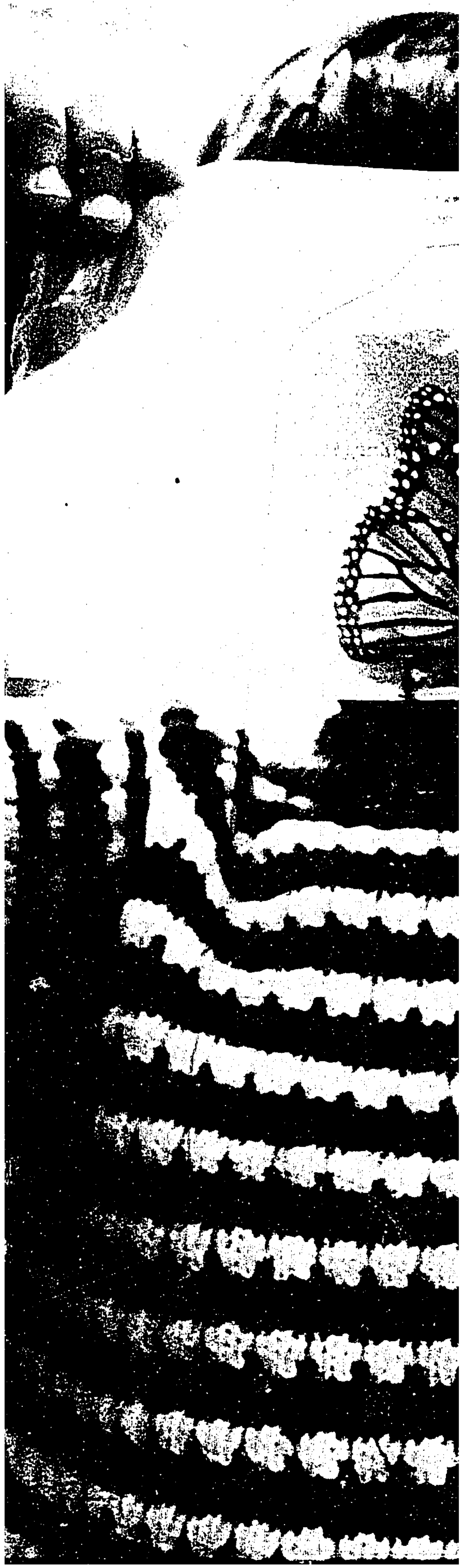
20. Programs must include student laboratory work.

The purpose of any science course is to help students learn science as an investigation process. Experimentation is a fundamental component for "understanding science." This understanding can best be gained by doing — not by reading about experimentation and inquiry. As much as 50% of any science course should be laboratory activities and investigations. Science courses must contain the kinds of activities rooted in the nature of science itself, regardless of title or clientele.

21. Science programs should be reviewed constantly.

Systematic examination of programs should determine changes in the nature of science and the constant changes in student needs and interests. Trends toward or away from the practical aspects of scientific knowledge tend to change emphases on product or processes of science. New courses may be needed to modify program functions. The work of external, national curriculum groups should be examined and, if the material developed seems to meet program needs, should be considered for adaptation. Teacher training needs should be considered during all the planning and implementation stages.

* *Graduation Requirements for Public High Schools in Maryland*, The Division of Instruction, Maryland State Department of Education, p. 11.



Elementary School Science Facilities

Recommendations

22. The classroom environment for science activities in the elementary school must provide surface space and movement space that permits practical experiences.

Programs and materials in modern elementary science are focused upon practical activities. Children work on the activities in pairs, trios, and small groups. The activities are designed to encourage interaction among the children. Facilities required include space for tables or flat top desks that can be arranged and rearranged. Each set of four students should be able to use a work surface during the science activity period. Traffic space should be adequate for free movement between these flat surface areas so that materials can be passed out and shared freely. There should be walk areas between the work stations provided.

23. Each teaching station should have a "holding" area for ongoing projects and activities. Science activities generate setting-up on-going experiments and require this special space.

Many science activities in modern elementary science involve experiments or investigations which require that observations and measurements be made in the teaching area. The activities may take several days to a few weeks.

24. Adequate space for science learning centers should be included in all teaching areas.

Teaching stations should have space for science learning centers to assist and promote individualized instruction. Such spaces serve the following functions:

- Provide extension activities related to the regular science lesson;
- Give optional lessons similar to regular sciences lessons for children who need more than one experience;
- Provide a place where the regular lesson in science can be revisited by students who need more time to learn;
- Provide spaces for teachers and students to have continuing opportunities for exploring and discovering concepts in science;
- Foster parent and community involvement in enrichment of the classroom science program. These spaces should have electrical outlets.

25. Each teaching station should have an area for the independent pursuit of science activities. These areas can be shared with other disciplines on a rotation basis.

Independent study activities and classroom projects for small groups are encouraged by current science programs. The continuing emphasis on individualization of activities and instruction requires space for gifted, handicapped, and students with learning disabilities.

26. Tables or areas should be provided to accommodate science demonstrations. These areas should include electrical outlets and sinks.

27. A "wet area," having outlets for electricity and water, should be located in each instructional area or between groups of instructional areas.

Wet areas serve multiple purposes, but are especially important for implementing good science programs.

28. Ample space in classroom areas is needed for day-to-day storage of science supplies and materials.

Kits and laboratory materials are real and necessary parts of modern science programs, and require adequate storage space when not in use.

29. Central storage spaces with adequate shelving to store science kits and materials should be provided.

These spaces should be easily accessible to the instructional areas and should be lockable. These spaces could be part of the central storage areas serving the entire school.

30. Plant growth areas with sufficient artificial lighting and other simulated environmental needs should be provided. Greenhouse facilities may be considered for total school programs.

Experiments or investigations that involve growing plants are increasing. Each grade level has some science activities viewing plant growth. Interior court areas may be considered and developed as possible plant growth areas for schools.

31. School grounds should be landscaped with the science curriculum in mind. Plants, trees, grasses, shrubs, and rock formations should be preserved if on site, and arranged for if not.

Increased awareness of environments as sources of inquiry and discovery lessons mandates that school grounds be given as much attention as buildings. Portions of sites should be preserved in as near their natural states as possible.

32. Science laboratory rooms provide unique and important elementary science resources.

Where these facilities are provided, teachers with special science training must be assigned to coordinate and implement the science activities in these spaces.

33. Office spaces with work surfaces, chairs, and storage to accommodate books, files, and personal items, should be provided for each teacher.

School plants must include adequate space for teacher planning. The space should be conducive to individual and team planning. Areas should be arranged to permit easy communication between team areas. Areas may be adjacent to teaching stations or located elsewhere in school facilities.

34. Planetaria facilities provide important and unique experiences. The content area of "the changing universe" is an integral and necessary part of each child's science education in the K-6 program. Such facilities, if provided, should be able to handle two or three visits per year for all third, fourth, and fifth grade students.

Local planetaria should serve clusters of schools. Each planetarium must have a full-time coordinator to effectively implement meaningful programs.

35. A school system should provide residential outdoor science experiences for all fifth and/or sixth grade pupils.

Environmental studies and science are accentuated by intensive encounters with the environment. Humans are making increased demands upon the natural environment. Literacy in science for children means that they should have real experiences dealing with the implications of these increased demands.

Secondary School Science Facilities

Recommendations

36. Appropriate laboratory spaces should be provided to accommodate each kind of science course.

Facilities should effectively promote learning in the earth and space, general and integrated, life and physical sciences. If a school's science enrollment is large enough, separate facilities should be provided for each of the sciences. For smaller school enrollments, multi-purpose laboratories should be considered — with either biological or physical science orientations.

37. Sufficient laboratory space to accommodate all students who need or wish to take science should be provided.

Schools should avoid scheduling students into laboratories every period of the day. Time is needed for cleaning-up and organizing for later activities. Laboratory facilities should be scheduled for about 85% usage. In the State of Maryland, almost all students through the tenth grade are enrolled in science. In grades 11 and 12, science is an elective subject. Depending upon the county and the individual school involved, 70 to 80% of students in 9th through 12th grades are enrolled in science courses.

38. The numbers of students in laboratory groups must allow for the proper supervision of learning activities from instructional and safety points of view.

The number of students assigned to a laboratory must never exceed the number of students for which that laboratory was designed. No laboratory group should exceed 28 students. Useful laboratory work, the heart of modern science instruction, requires individual participation by students and close student-teacher liaison. To increase the number above that recommended is to jeopardize the educational value of science experimentation and inquiry and creates an unmanageable and unsafe laboratory environment. The risk to student safety escalates rapidly as the number of students in the laboratory at one time increases. Fifty percent or more of the time, science activities involve the use of acids, hot materials, open flames, glass and biological agents. Each of these offers its own kind of special potential human hazard. It is, therefore, imperative that the maximum number of students in laboratories be limited to the number of students for which those laboratories were designed.

39. Laboratories should have adequate gas, water, and electrical utilities, in convenient locations to accommodate the students who will use the areas.

There should be one sink for every four students assigned to a laboratory. They should be of sufficient size, (at least 10" x 12" x 8") to facilitate the washing of glassware and the obtaining of water. They should be spaced and located conveniently throughout the laboratory. One sink should be installed that is large enough to clean aquarias and deep enough to secure water to wash large graduate cylinders. Cold water should be provided at every sink. At least one hot water tap for every 28 students should be provided.

One electrical outlet should be installed for every student. Fourteen duplex receptacles would be adequate for classes of 28 students.

There should be one gas cock for every student. Fourteen double or 28 single gas cocks should be provided for 28 students. A master control valve must be included in every laboratory.

If fixed demonstration tables are included in laboratory facilities, they should have double gas cocks, hot and cold water, large sinks, and two duplex electrical outlets.

40. Waste disposal facilities must be provided in all laboratories.

Sinks with lead or special plastic piping, non-corrosive waste receptacles, and fume hoods in chemistry and other laboratories where noxious and unpleasant gases may be generated, should be installed in each laboratory. Provisions should be made for the disposal of paper, chemicals, and broken glassware.

41. Space must be provided to accommodate non-laboratory activities of science.

Lectures, discussions, demonstrations, tests, and films are all important activities in a good science program. Some of these activities occur in every science class every day. Therefore, adequate space to seat all the students enrolled in the science program at any given hour is necessary. Spaces should be divisable into units that will accommodate individual classes. Some spaces should have full audiovisual capability. Sixteen to 24 linear feet of chalkboard and 6 to 8 feet of tackboard should be provided for each group of 28 students. Display cases are also recommended for these areas.

42. The following environmental conditions should be provided:

Visual — Lighting should be provided that will facilitate all instructional activities particular to science. Science teaching stations should have lighting which takes into account the working variances common to science facilities. Glare should be avoided. Each teaching station should be provided with its own light control(s). Visual accessibility between spaces should be built into science facilities where supervision and safety considerations can be enhanced, i.e., visual access from a laboratory to a special project area or a preparation area — or from one lab to another where appropriate.

Thermal — Science teaching stations should be planned for year-round use. Individual controls for heat and ventilation should be included in each laboratory.

Acoustical — Laboratories should be designed so that a minimum of sound reverberation occurs. The facility should be constructed so that groups of students can function within a given laboratory and in related adjacent instructional areas without undue interference.

Ventilation — Ventilation systems should be installed that will provide for the comfort and health required in each laboratory. Each laboratory should have the capability of renewing the room air at the rate compatible with normal student occupancy and the potential use of science laboratories such as maintenance of animals, and the release of noxious gases. Particular attention should be given to proper ventilation in the chemistry laboratories, chemistry storage rooms and preparation areas. Fume hoods should be installed in all laboratories where chemistry is taught. The "Island hood" with four sides (two removable sides) is recommended. This hood allows a teacher to demonstrate on one side and have students observe on the other sides. Gas cocks, water and electrical outlets should be included in hoods.

Spatial — Sufficient space should be provided to accommodate all kinds of learning activities, laboratory, discussion, use of printed materials, lecture, audiovisuals, group, and independent study.

43. Adequate storage should be provided.

A central storage area should be located convenient to preparation rooms and laboratory areas. Shelving, varied in depth to accommodate a diverse type of storage requirements, should be used. This storage is in addition to the storage space provided in each laboratory.

Chemical storage should be available near to or as part of central storage areas. Large areas next to the floor should be used for storing acids. Acid resistant, adjustable shelving should be used.

A toxic room must be provided for the storage of flammable, volatile, and highly poisonous or hazardous chemicals such as sodium, ether, and carbon tetrachloride. Such precautions are required by the OSHA-MOSHA law. For information relative to size, design and type of material used in the construction of these rooms, see publication 29 CFR 1910 — "Maryland Occupational Safety and Health Standards" (MOSHA), Section 106(d), p. 22177.

Wall and base cabinets should be provided for the storage of glassware, ringstands, tripods, bunsen burners, test tubes in laboratories. Such storage reduces cross-room movement, makes students responsible for their own equipment, and results in less breakage and fewer accidents.

Tote trays should be provided, especially in the implementation of self-pacing and individualized science programs.

44. Safe working conditions for students and teachers must be provided in the laboratory.

All laboratories where chemistry is taught must contain emergency eye-washes and shower stalls.

Fire blankets and fully operable fire extinguishers must be located where they are quickly accessible in each laboratory.

The State Fire Marshall's code requires two exits for all science rooms. Exits should open into main passages or to the outsides of buildings.

All gas jets must have master control valves for each laboratory. Consistent with the OSHA-MOSHA Act, schools should receive annual safety checks of each laboratory during the summer by school systems' safety offices.

The maximum number of students assigned to laboratories must not exceed the number for which they were designed.

45. Areas for plant growth must be provided.

Specialized facilities for potting and growing plants are essential to good life science programs. This need can be met through several alternatives. (a) Greenhouses can be provided adjacent to life science or biology rooms. There should be direct access from classrooms to greenhouses. Programs assuring utilization must be developed. Staff must be provided to manage greenhouses and implement programs. (b) Indoor spaces can be designated plant growth areas, but require special consideration of environmental controls including temperature, humidity and light. (c) Commercially-made growth chambers can be provided.

46. Darkrooms should be provided.

Such rooms can be used for photography instruction, and for science experiments which require light control.

A program which assures their use must be developed. Staff must be provided to manage the facilities and implement programs.

47. Special animal growth and care areas should be provided where activities involving live animals are part of the program.

The health of students and teachers must be carefully considered. Animals must be properly cared for. Such areas should be vented to the outside to eliminate odors. Programs which assure their use must be developed. Staff must be provided to manage facilities and implement programs.

48. Space for repairing and constructing special equipment should be provided in science areas.

Such space should be used for activities and projects requiring construction of special equipment. These areas may include workbooks, vices, and related tools.

49. Project rooms must be provided for individual and small group activities.

They should be located to allow teacher supervision from adjacent areas. A work counter, gas, a sink with hot and cold water taps, and electricity should be provided for each work station. Base and wall cabinets should be included that contain individual locks. One-third of a cubic meter of storage per station should be provided. Chalkboard and tack board should be provided in these areas.

50. Space for science libraries should be included only if provisions are made for supervising the materials.

51. Space for conferences and small group meetings should be provided in or near science areas.

52. Teachers' office spaces should be positioned close to science instructional areas.

Such offices should allow for both formal and informal conversations among science teachers. They should afford opportunities to share and develop curriculum ideas on day-to-day bases. They should include a work surface, chair, book storage, files, and personal items for each teacher.

53. A preparation area should be provided.

This area is vital to science functions. The daily preparation of solutions and the organizing of materials for laboratory use is a continuing, on-going activity that must be provided for. This room should be located in proximity to central storage and should be accessible for use by students, teacher aides, and teachers.

54. School grounds should be landscaped with science curricula in mind. Plants, trees, grasses, shrubs, and rock formations should be preserved if on site, and arranged for if not.

School grounds should be given as much attention as the building itself. A portion of the site should be preserved in as near its natural state as possible.

55. Planetarium facilities provide important and unique experiences. The content area of "the changing universe" is an integral and necessary part of each student's science education in grades 6-12.

Local planetaria should serve clusters of schools. Each planetarium must have a full-time coordinator to effectively implement meaningful programs.

Science Furniture And Equipment

Science furniture and equipment must be considered in the initial stages of facilities planning. Once a description of the available space, planned activities, and new and expanded anticipated programs is available, furniture and equipment should be selected. Planners should first identify basic functional requirements for furniture and equipment, and then give attention to selection of individual units. Criteria should be developed and used in selecting these items. The following general criteria will assist the selection of science furniture and equipment:

Appearance — Units should be designed to harmonize with the architectural surroundings. Educational complexes must be inviting places to learn and have stimulating atmospheres.

Flexibility — Furniture and equipment should fulfill current needs and have qualities which render them usable for future requirements.

Safety — Furniture and equipment should be fire retardant. When burning, they should not produce toxic gases or smoke in quantities which could endanger occupants before areas are evacuated. They should be non-allergenic and stable. They should not have dangerous protrusions, easily pinch fingers, or collapse. Corners, edges, and hardware should be designed to prevent injury. All edges should be rounded and, where possible, composed of or covered with resilient materials.

Durability — Units should be constructed of durable materials.

Maintenance — Units should be as maintenance free as possible. Replacement parts should be easily obtainable.

Comfort — Furniture and equipment should be the right height for the function required. Light reflectance (color, glare, contrast, etc.) acoustics, form, and scale are other elements to be considered in determining comfort.

Building Codes — Prior to the purchase of furnishings, assurance must be made that units chosen adhere to all applicable building codes.

Guarantees — Units should carry at least one year guarantees against defects in workmanship and materials.

Cost — After all other criteria have been satisfied, cost may be considered. Lower priced units may lack durability, fail to fulfill the educational requirements, lack safety features, or violate many other functions which are more important than initial cost.

Services of the manufacturer and/or distributor — Manufacturer's willingness to repair or replace faulty items, ability to meet delivery dates, quality of installation and clean-up, and willingness to modify standard products when required on large orders are significant factors. Suppliers should be close enough to provide service in a reasonable amount of time.

Specifications

Specifications should be prepared to describe in detail quality of furnishings and equipment. Preferred terms under which these items are to be constructed, assembled, and set in place must also be included.

Specifications are usually written by the purchasing agent, architect, or science consultant, or by a combination of these individuals. They should be written simply and precisely.

Great care should be exercised to assure that the products obtained meet the needs of the educational program even though they may be furnished by different sources. For instance, all of the furniture and equipment in the science area should be matching and harmonious. All of the cabinets and casework should be provided by the same manufacturer to allow interchangeability.

Particular care should be exercised when items must be used in more than one configuration. An example is tote trays. When stored, they must fit easily on a shelf or in a cabinet. If they are intended to be fitted into or under desks or tables, they must do so readily. When they are in use by students, they must perform properly.

Specifications must inform potential suppliers of the intended use of the product. In preparing specifications, the term "or equal" should be used carefully. Bidders are sometimes tempted to interpret the "or equal" proviso as an invitation to offer items which are similar, but do not meet actual requirements. *It is the user's responsibility to determine if the product offered is, in fact, equal!*

Recommendations

56. Science equipment and materials should relate directly to the needs of students as set forth by the curriculum and curricular trends.

All equipment must contribute specifically to the objectives of instructional programs.

All equipment should reflect schools' efforts to introduce improvements into programs — different sequences of study, increased offerings, continual sequential development, etc.

Equipment should be specified to stimulate students' interests and desirable attitudes toward the subjects.

57. Science equipment and materials must be suitable for the subjects concerned.

All equipment must indicate a proper balance between students' participation in laboratory activities and teacher demonstrations and presentations.

The specified equipment must be appropriate for the grade level and type of activity in which it will be used.

Equipment specified must be compatible with educational programs offered or planned by schools.

Science equipment and materials must provide a learning potential not otherwise available in science programs.

58. Adequate equipment must be specified to cover the quantity and variety of experiences required by science programs.

The amount and type of equipment and materials must be sufficient for the number of teachers and students for which the areas are designed.

The quality and durability of the equipment should be equal to its required performance.

Facilities for both use and storage must be provided to accommodate all required equipment.

Consideration must be given to the reliability of science equipment and arrangements should be made for proper maintenance and service when needed.

59. Proper and adequate case work and furniture must be provided in the laboratory, preparation rooms, resource areas, conference rooms, project rooms, and other supporting areas.

These items should be included in the specifications for the facility and installed by the general contractor.

Examples of some of these items are as follows:

Laboratory tables
Storage cases
Wall cabinets
Base cabinets
Display cases
Demonstration tables
Special project benches
Sinks and/or sink assemblies
Wardrobes
Shelving
Refrigerators
Controlled environmental cabinets
Key cabinets
Safety cabinets
Fume hoods
Chalk boards
Bulletin boards
Fire extinguishers and blankets
Safety showers
Eye wash fountains
Carrels

The following criteria are suggested for selecting science case work and furniture:

The furniture must be educationally correct. Its positioning (placement) must be designed to allow unhampered and diverse activities, and provide for functional adaptation to meet both present and future requirements in effective science programs.

Close grained hardwoods, heavy gauge metal which has been treated to prevent corrosion, good quality plastic laminates or strong solid or formed plastics should be used.

Where hardwood construction is considered:

- framing should be solid hardwood.
- all primary joints should be hardwood to hardwood.
- all primary joints should be mortised and tenoned.
- all primary joints should be glued and screwed or secured with mechanical fasteners.
- all hinges, locks, faucets, and other hardware should be of heavy institutional quality.
- all plumbing attachments and drain lines should be resistant to acids, alkalis, and solvents.

Where other basic construction materials are used such as metal or plastic, similar factors should be considered.

All finishes should be resistant to chemical and abrasive action and should be attractive and durable.

The length, width, height, shape, and weight of tables, cabinets, hoods, and other furniture must be considered.

Safety features should be specified to assure the utmost protection for teachers and students.

Most counter and table tops should be either solid monolithic asbestos, impregnated, and surfaced with acid, alkali, and solvent resistant material, or natural stone impregnated and surfaced with acid, alkali, and solvent resistant resinous coatings. Tables and some counter tops may be made of wood fiber resin bonded sheets laminated with waterproof cement with a resin coated surface which offers resistance to heat and concentrated chemicals. High pressure laminates of a minimum of .032 in thickness over plywood or minimum 45 lb. particle board cores may be used as tops for student tables and counters, where limited resistance to heat and concentrated chemicals is sufficient.

High pressure laminates should *not* be used where any of the following reagents are expected to come into contact with the laminate surfaces:

hypochlorite bleach
hydrogen peroxide
sulphuric, hydrochloric, or nitric acids
lye solutions
sodium bisulphite
potassium permanganate
gentian violet
silver protein
bluing or dye
alcohol containing iodine
berry juices
silver nitrate

(Tops of monolithic asbestos or stone should be specified when any of these products are expected to be used. Glass reinforced polyester may be specified in lieu of asbestos or stone under certain conditions and where the weight of objects to be used is not great.)

Tops of solid plastic, glass reinforced polyester, steel, galvanized steel, or bonded lead sheet may be used to meet specific needs.

Hardwood edge-grain tops should be used on project work benches where heat and chemical resistance is not required. Top thickness may vary from 1¼" to 2¼" depending on strength requirements.

Steel bench tops should be minimally 12 gauge material bonderized and finished on all surfaces with an abrasion resistant baked enamel. All metal tops should have rolled or formed edges returned a minimum of 1" in both front and back and should be sound-deadened.

Supporting services or utilities such as gas, water, air, and electricity; as well as drains, vents and hoods should be specified of proper size, type, and location to conveniently facilitate the activities to be undertaken.

Electric outlets and ventilation equipment for animal enclosures should be conveniently located, and, either on emergency circuits or fitted with alarms, observable from both inside and outside of the building, so that interruptions to normal power sources will not result in discomfort or death to the inhabitants.

60. Movable furniture and equipment items must be provided in science areas. These items are not usually furnished by building contractors. They include:

Teacher desks	General purpose tables
Teacher chairs	Stools
Pencil sharpeners	Soap dispensers
File cabinets	Paper towel dispensers
Student seats	
Work benches	
Wastebaskets	

61. Equipment for experiments, demonstrations, and related activities on a day-by-day basis must be provided.

This equipment is selected by science

supervisors and science teachers to provide opportunities for varied experiences required by the educational programs for both students and teachers.

These items should be provided in quantities adequate for two-student laboratory work. New items are added constantly in this fast developing field; however, examples follow:

Electrical devices:

Battery chargers
Coils
Generators
Hot plates
Incubators
Meters
Motors
Power supply units
Rectifiers
Rheostats
Solar cells
Switches
Transformers

Glass and porcelain ware:

Battery jars
Beakers
Bottles
Burettes
Capillary tubes
Crucibles
Flasks
Funnels
Microscope slides and cover slips
Mortars and pestles
Petri dishes
Pipettes
Stoppers
Vials
Watch glasses

Kits:

Electrical circuit
Electronic
Embedding
Polarized light
Transistor

Measuring and recording devices:

Balances and weights
Barometers
Boyle's law apparatuses
Calipers
Counters and timers
Calorimeters
Eudiometers
Hydrometers
Manometers
Meter sticks
Meters and gauges
Scalers
Tachometers
Thermometers

Models and display materials:

Anatomical models
Atomic models
Biological models
Collections (insect, rock, plant, etc.)
Embedded biologicals
Skeletal mounts
Specimen mounts

Optical devices:

Binoculars
Lenses
Light filters
Magnifiers
Microscopes
Mirrors
Prisms
Telescopes

Other laboratory equipment:

Aquaria
Aspirators
Autoclaves
Cages
Calculators
Cathode ray tubes
Clamps
Cloud chambers
Color apparatuses
Computer/access to terminal
Demonstration radio transmitters and receivers
Desiccators
Fire extinguishers (demonstration)
Germinating beds
Growing frames
Gyroscopes
Heat sources
Horsepower apparatuses
Insect mounting boards
Laboratory carts
Laboratory tables
Laser and Holographic equipment
Linear expansion apparatuses
Liter blocks
Magdeburg hemispheres
Magnets
Microtomes
Mock-ups
Nets
Optical benches
Oscilloscopes
Photoelectric cells
Photometers
Planetaria
Pulleys
Pumps
Radiometers
Ripple tanks
Simple machine apparatuses
Spectroscopes
Steam generators
Sterilizers
Stethoscopes
Stoppers (rubber)
Stroboscopes
Terrariums
Tongs
Transectory apparatuses
Tubing (rubber or plastic)
Tuning forks
Van de Graaff generators
Vasculums
Vivariums
Water baths

62. Audiovisual equipment should be provided.

Films, filmstrips, films loops, video tapes, overhead transparancies, and charts are all needed in teaching science.

The following is a partial list of audiovisual equipment which may be used in teaching science:

Darkening shades, blinds, or curtains;
Filmstrip and/or slide previewers;
Flannel and magnetic boards;
Microfilm reader printers;
Portable stands with sound amplification for large-group teaching;
Projection screens, stands, and tables;
Projectors: 16mm and 8mm film
Filmstrip
Microfilm
Microprojector
Opaque
Overhead

Slide
Filmloop cartridge projector
Cameras — still (35 mm, polaroid), movie and television;

Record or cassette players;
Copying/duplicating machines;
Stereoscopes;
Tape recorders and playback units;
Video tape recorders/players (VTR units);
Television receivers/monitors.

63. Supplies must be provided to support science programs.

These items are consumed in use. Annual appropriations are needed to replace them. The materials in this category are, of course, selected by science supervisors and teachers. Some examples of groups of these items are:

Aquaria and terraria supplies;
Biological chemicals and media;
Chemical reagents;
Living specimens;
Preserved specimens;
Miscellaneous supplies.

64. Adequate collections of printed materials such as textbooks, resource books, magazines, pamphlets, and circulars must be provided.

Installation

The installation process is the final step in the long, complex system of obtaining the proper furnishings. It should not be viewed as something that requires little attention. The best method for final procurement and proper installation of furnishings is through use of a check list. The assistance of architects, interior designers, and/or equipment consultants can aid final evaluation of installation. Key points of the installation process are:

When the building has progressed sufficiently to allow installation, assurance must be made that the equipment will be delivered and installation crews will be present. Be sure furniture and equipment suppliers are aware of the building completion date.

All wall-mounted cabinet units should be securely fastened. All doors and drawers should operate smoothly. All units purchased should actually be delivered and installed, and be as specified in the contract. All mechanical and electrical items should be functioning properly.

Recommendations

65. Spatial requirements must be based upon program need. The following procedure is recommended for determining spatial needs. First, the number of teaching stations required should be determined. Second, the activities to occur in each teaching station should be defined. Third, the projected activities should be translated into square foot requirements.

The following procedure uses program definitions to determine the total number of teaching stations required:

Step 1 Total enrollment for which the school is to be designed is determined.

Step 2 The percentage of the total enrollment that will be involved in science activities during one day is determined.

Step 3 The anticipated maximum class size is determined.

Step 4 The number of periods per day is determined.

Step 5 The number of periods per day is multiplied by the maximum class size.

Step 6 A reasonable factor of space utilization (usually 85%) to allow for program flexibility is determined. The total from step 5 is multiplied by the utilization factor to determine the maximum number of students one teaching station can handle in a day.

Step 7 The number of students taking science in one day is divided by the maximum daily load of one teaching station to determine the required number of teaching stations for the science program.

Example:

Step 1 1,200 projected student enrollment.

Step 2 80% of student enrollment will be taking science in one day or 960 students.

Step 3 28 students is the anticipated maximum class size.

Step 4 There are 6 periods/day.

Step 5 6 periods/day x 28 students/teaching station/period = 168 students/teaching station/day.

Step 6 .85 utilization factor x 168 students/teaching station/day = 143 students/teaching station/day.

Step 7 960 students ÷ 143 students/teaching station/day = 6.71 or 7 teaching stations/day required for the science program.

Next, the activities to take place within or adjacent to each teaching station should be articulated. The philosophy and curricula of the local school district will dictate these activities. The activities, in turn, will dictate the square footage requirements.

The following guide for determining square footage requirements is filled out for each teaching station and based on activities projected in that teaching station. As a guide, however, it is only a basis from which to begin planning. The activities in the following table may not be all inclusive or defined correctly for your particular program. This guide should be used in consultation with science educators and facility planners.

________ Teaching Station

Activity	Square Foot Guidelines	No. of Persons	×	Square Feet Per Person	=	Required Net Square Feet
General Instructional						
Laboratory Work	A minimum of 35 sq. ft per student served. (This figure includes space for work surface, storage, utilities, chalk, and/or tack boards, internal circulation, emergency equipment, special study centers, and demonstration areas if required.)		×		=	
Lecture/ Discussion This space may be combined and shared between teaching stations, combined and shared as a department or allocated to each teaching station exclusively.	A minimum of 12 sq. ft. per student served. (This projection assumes activities which are relatively inactive and/or are lecture-type experiences.)		×		=	
Central Storage Other than laboratory.	A minimum of 2 sq. ft. per student served.		×		=	
Preparation	A minimum of 3 sq. ft. per student served.		×		=	
			Total Net Sq. Ft. Required for Teaching Station		=	

Example

Chemistry **Teaching Station**

Activity	Square Foot Guidelines	No. of Persons	×	Square Feet Per Person	=	Required Net Square Feet
General Instructional						
Laboratory Work	A minimum of 35 sq. ft. per student served. (This figure includes space for work surface, storage, utilities, chalk, and/or tack boards, internal circulation, emergency equipment, special study centers, and demonstration areas if required.)	[illegible]	×	35	=	980
Lecture/ Discussion This space may be combined and shared between teaching stations, combined and shared as a department or allocated to each teaching station exclusively.	A minimum of 12 sq. ft. per student served. (This projection assumes activities which are relatively inactive and/or are lecture-type experiences.)	28	×	12	=	336
Central Storage Other than laboratory.	A minimum of 2 sq. ft. per student served.	28	×	2	=	56
Preparation	A minimum of 3 sq. ft. per student served.	28	×	3	=	84
				Total Net Sq. Ft. Required for Teaching ing Station	=	1456

The following guide for determining square footage requirements is filled out for the entire Science Department.

Departmental Science Activities

Activity	Square Foot Guidelines	No. of Persons or Spaces Involved	×	Square Feet Per Person or Space	=	Required Net Square Feet
Individual and Small Group Space for these activities may be shared by more than one teaching station						
Special Projects—a minimum of one for every two teaching stations	A minimum of 100 sq. ft. or 25 sq. ft. per student.		×		=	
Photography—a minimum of one per department	A minimum of 80 sq. ft. or 30 sq. ft. per student.		×		=	
Plant Growth—a minimum of one alternative per department	There are three basic alternatives: (1) Commercially produced chambers at 20 sq. ft. per chamber. (2) Plant growth rooms at a minimum of 200 sq. ft. (3) Greenhouses at a minimum of 400 sq. ft.		×		=	
Animal Study—a minimum of one alternative per department	There are two basic alternatives: (1) Commercially produced chambers at 20 sq. ft. per chamber. (2) Animal study rooms at a minimum of 150 sq. ft.		×		=	
Conference/Seminar—a minimum of one per department	A minimum of 100 sq. ft. or 15 sq. ft. per student.		×		=	
Teacher and Teacher Aid						
Teacher Planning	A minimum of 50 sq. ft. per professional.		×		=	
			Total Net Square Feet Required		=	

Example
Departmental Science Activities

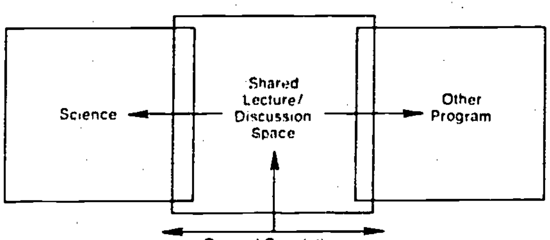
Activity	Square Foot Guidelines	No. of Persons or Spaces Involved	×	Square Feet Per Person or Space	=	Required Net Square Feet
Individual and Small Group						
Space for these activities may be shared by more than one teaching station						
Special Projects—a minimum of one for every two teaching stations	A minimum of 100 sq. ft. or 25 sq. ft. per student.	3 rooms	×	100	=	300
Photography—a minimum of one per department	A minimum of 80 sq. ft. or 30 sq. ft. per student.	6 students	×	30	=	180
Plant Growth—a minimum of one alternative per department	There are three basic alternatives: (1) Commercially produced chambers at 20 sq. ft. per chamber. (2) Plant growth rooms at a minimum of 200 sq. ft. (3) Greenhouses at a minimum of 400 sq. ft.	1 Greenhouse	×	500	=	500
Animal Study—a minimum of one alternative per department	There are two basic alternatives: (1) Commercially produced chambers at 20 sq. ft. per chamber. (2) Animal study rooms at a minimum of 150 sq. ft.	2 chambers	×	20	=	40
Conference/ Seminar—a minimum of one per department	A minimum of 100 sq. ft. or 15 sq. ft. per student.	1 space	×	100	=	100
Teacher and Teacher Aid						
Teacher Planning	A minimum of 50 sq. ft. per professional.	8 teachers	×	50	=	400
				Total Net Square Feet Required	=	1520

66. The space in which laboratory activities occur should be neither excessively long nor narrow, and should have circulation patterns which avoid confusion, confinement, or create long travel distances.

Safety is of great importance in the laboratory. Good visual and verbal communication between teachers and students is critical in order to avoid accidents, to act quickly in emergency situations, and to enhance student observation of teacher demonstrations.

67. Where different programs in the school require the same or similar facilities, sharing should be considered.

The feasibility for sharing space among programs involves careful study of the demands placed on particular spaces. For example, a particular science program may require the use of 7.5 teaching stations and another program 6.5 teaching stations. The two programs might, therefore, share lecture and discussion spaces. When lecture and discussion spaces are shared with another program, these areas should be physically separated from laboratory spaces. When programs share space, these programs should be located adjacent to each other.



68. Space sharing within science programs should be considered.

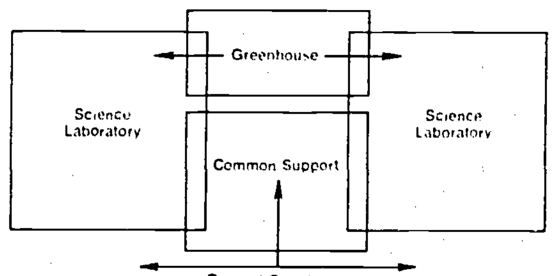
For efficient utilization of space, the following areas should be planned and located to accommodate a maximum amount of space sharing within science programs.

Conference	Special Projects
Preparation	Storage
Plant Study	Lecture/Discussion
Animal Study	

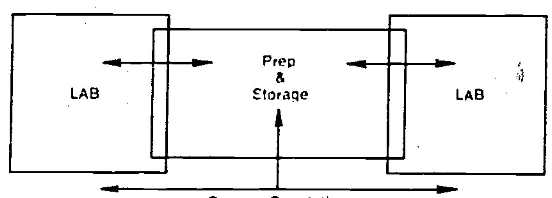
In designing and locating these areas, safety and supervision should be considered.

69. Greenhouses or plant study rooms should be adjacent to those teaching stations most involved with plant study activities.

Access to instructional spaces increases utilization and proper management of this space.



70. Access to laboratory support spaces should not require transit of laboratories.



71. Direct physical and visual access to the out-of-doors is essential for science programs.

With increased emphasis on environmental studies, out-of-doors experiments should be conducted. Physical and visual observation of these experiments should be possible from science instructional areas.

Safety and Security

Requirements for both safety and security are less stringent and complex in conventional instructional spaces than in science laboratory areas.

General recommendations for planning safe and secure science spaces are:

72. Provisions pertaining to science facilities in the Maryland Occupational Safety and Health Act (MOSHA) should be strictly followed.

Planners should be familiar with the Act or should obtain the services of consultive persons or agencies. Provisions of the Act should be incorporated throughout the planning process to occupancy of the space.

73. Provisions pertaining to local and state fire marshall's requirements should be strictly followed.

In many cases, local requirements for safety are more stringent than the OSHA Act; therefore, continuous local coordination is imperative to insure code compliance.

74. The number of students assigned to science laboratories should never exceed the number for which those spaces were designed.

75. Provision should be made to allow adequate movement of individuals.

A free flow of students and instructor is necessary. Students should be able to move from activity to activity with accompanying materials. Spaces should be adequate and furniture and equipment properly arranged to permit movement without injury to occupants.

76. Provision should be made for visual and auditory supervision.

Spaces should provide for adult supervision. Adequate visual and auditory access by the instructor is a necessary part of the safety and security of such facilities. Carefully planned spaces can reduce accidents and injuries.

77. Provisions should be made for adequate lighting and ventilation.

These two considerations should be incorporated into science space planning. In addition, with the types of materials and equipment, care must be exercised in providing temperature control to suit the activity or situation. These provisions are necessary from the point of view of safe chemical storage and the need to prevent the loss of costly living organisms used in the instructional program.

78. Furniture and equipment should be chosen, designed, and installed with health and safety in mind.

79. Provisions should be made for storing nonflammable materials in locked storage areas.

80. Provisions should be made for storing flammable materials in locked storage areas.

81. Provisions should be made for high capacity, continuous forced ventilation.

All areas, but in particular where chemicals are used, need ventilation. Such ventilation aids student efficiency and health.

82. Fire blankets and extinguishers should be easily accessible to student laboratory areas.

These units should be placed within easy reach or vision of students' work areas. Instruction in their use should be a normal and continuous part of the programs.

83. Safety showers and eyewash fountains should be provided in areas where chemicals or other flammable materials are used.

84. Efficient fume hoods should be provided.

Concentrated fume control over and above forced ventilation is necessary to insure control of dangerous fumes. These fume hoods should be provided for preparation areas, demonstration tables, and small group work areas where dangerous fumes are possible.

85. Safety goggles and face masks should be provided.

86. Electrical and gas services should be controlled by instructors.

Steps In The Planning And Construction Process

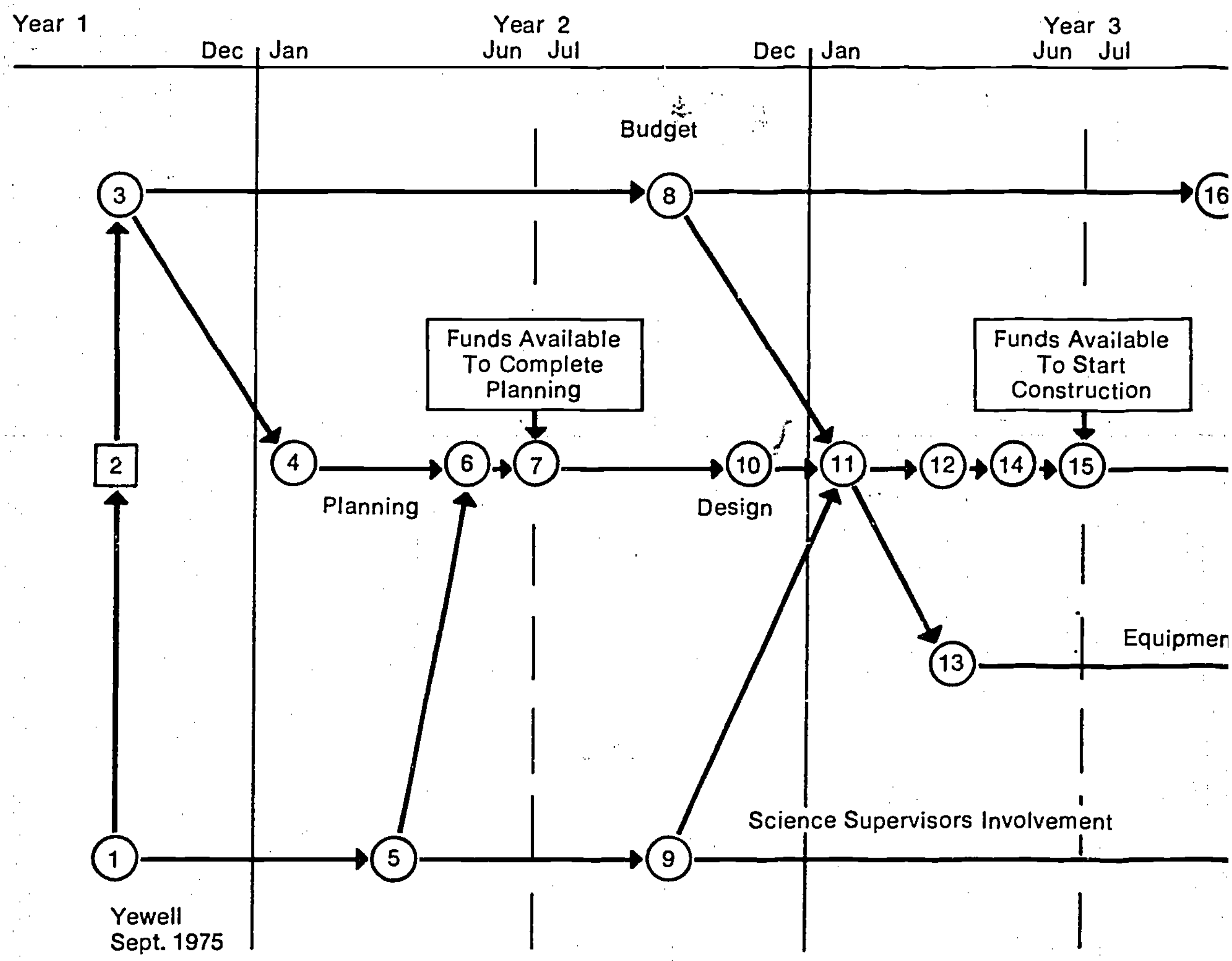
Activity or Event	Description	Time Reference	Who Involved
1-2	Identification of need for project	Before activity 2-3	S/C
2-3	Preparation of proposal for feasibility study or planning funds	Summer Year 1	S/C
3	Submit Capital Improvement Program to Interagency Committee	By October 1, Year 1	C
4-6	Write educational specifications		C/I
5-6	Participate in preparation of educational specifications		S
6	Submit educational specifications to Interagency Committee	By May 1, Year 2	C
6-7	Prepare schematic drawings		A
7	Submit schematics to Interagency Committee	By July 1, Year 2	C
8	Submit Capital Improvement Plan to Interagency Committee for construction funds	By October 1, Year 2	C
5-9	Participate in preparation of design development and construction documents—including equipment selection and layouts		S
10	Submit Design-Development Documents to Interagency Committee	Before end of November Year 2	C
11	Submit Construction Documents to Interagency Committee—including equipment layouts and lists	By February 1, Year 3	C
12	Construction Documents approved by Interagency Committee	By April 1, Year 3	I
13-17	Analyze and consolidate equipment requirements and advertise "Not in-Contract" items		P/S
14	Advertise construction contract		C
14-15	Analyze construction bids—including built-in equipment		C/S
15	Award construction contracts	On or after July 1, Year 3	C
15-21	Construction	July Year 3 through June Year 5	C
16	Submit Capital Improvement Program to Interagency Committee for movable equipment funds	By October 1, Year 3	C

Steps In The Planning And Construction Process (continued)

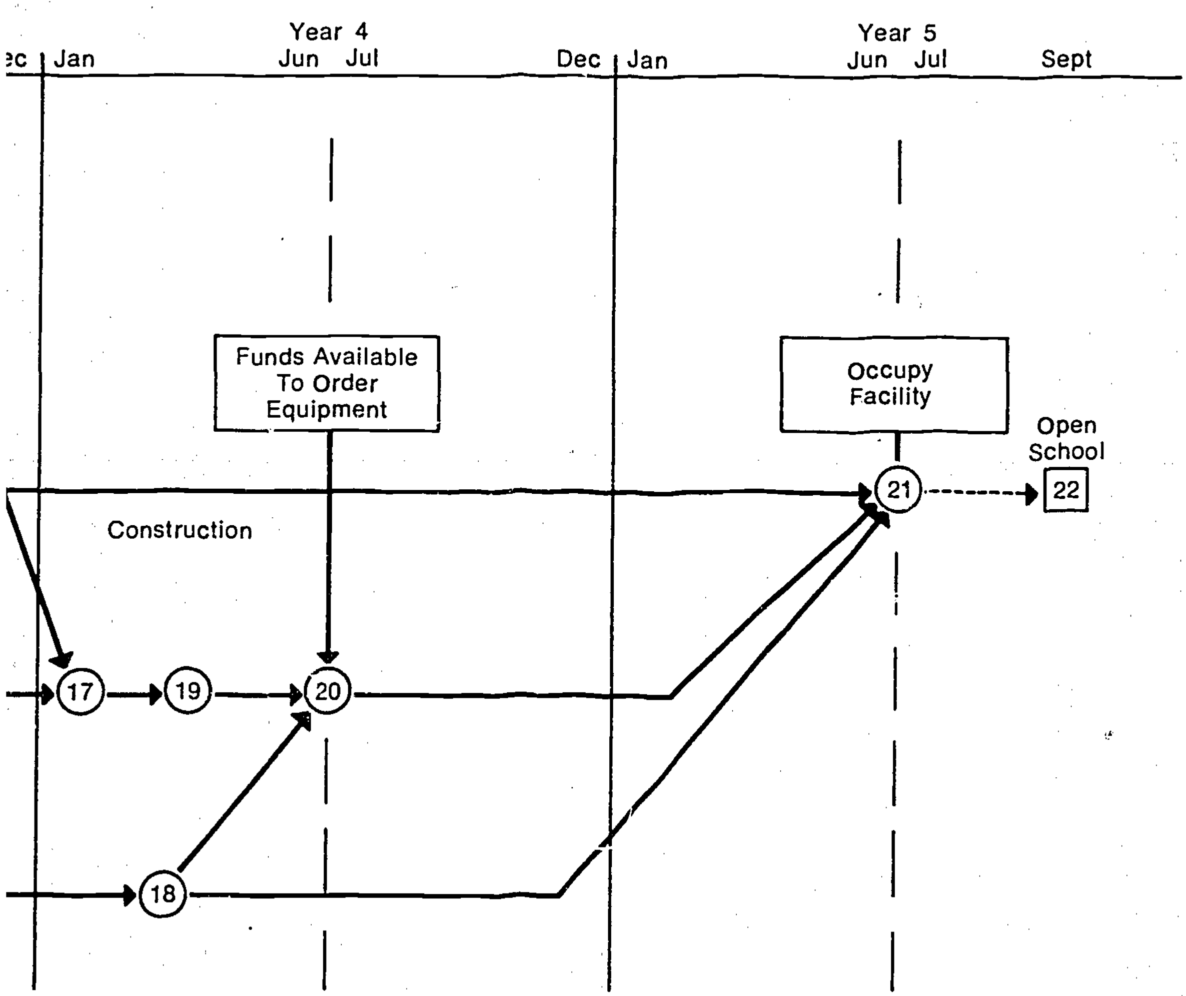
Activity or Event	Description	Time Reference	Who Involved
17-19	Advertise equipment contracts		P
18-20	Analyze equipment bids		P/S
20	Award equipment contracts	On or after July 1 Year 4	P
18-21	Monitor construction progress and equipment contracts	March Year 4 through June Year 5	C/S
21	Make final check of built-in and movable equipment	July-August Year 5	C/P/S
22	Open school	September, Year 5	

S — Science Supervisor
C — Construction Planning and Administrative Personnel
I — IAC Personnel
A — Architect
P — Procurement Personnel

The chart that follows illustrates the steps in the planning and construction process.



Year 1
Dec
Jan
Year 2
Jun
Jul
Dec
Jan
Year 3
Jun
Jul
Budget
3
8
16
Funds Available To Complete Planning
Funds Available To Start Construction
2
4
6
7
10
11
12
14
15
Planning
Design
13
Equipmen
Science Supervisors Involvement
1
5
9
Yewell
Sept. 1975



Year 4
ec Jan
Jun Jul
Dec Jan
Year 5
Jun Jul
Sept
Funds Available To Order Equipment
Occupy Facility
Open School
Construction
17
19
20
18
21
22